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Wetland classification and inventory: A summary

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Abstract

Regional, national and local wetland classifications have been developed and successfully applied. These have invariably been orientated towards conservation and management goals, and the information used to assess wetland loss or to assign management priorities. Existing national and regional classification systems have not only been useful, but they provide an essential base for developing an international system. At the international level, differences among existing systems in the definition of a wetland and how wetland types are defined assume great importance and need to be resolved. Classification is an essential prerequisite for wetland inventory. A number of international inventories have been undertaken, although these have not generally utilized the available high technology and data storage systems available through remote sensing and geographic information systems. More extensive international inventories will require standardization of techniques for data collection, storage and dissemination. A minimum data set needs to be defined with standards for data accuracy. An international committee under the auspices of an international agency (e.g. IWRB, Ramsar Bureau, IUCN) needs to be established to develop an international classification system and guidelines for carrying out a complete inventory of the world's wetlands.

Introduction

The information collected through wetland inventories is nowadays regarded as a necessary prerequisite for wetland conservation and management at a holistic level, involving planning on a national, regional and international scale (Dugan 1990; Hollis *et al.* 1992; Taylor *et al.* 1995; Hughes 1995; Naranjo 1995; Scott & Jones 1995). An inventory is regarded by Dugan (1990) as the first step in assembling an information base for wetland management. In fact, Contracting Parties to the Ramsar Convention undertake to compile an inventory as part of the process of developing and implementing a national wetland policy for the wise use of all wetlands on their territory.

The term 'wetland' groups together a wide range of habitats that share a number of common features, the most important of which is continuous, seasonal or periodic standing water or saturated soils. Under the widely accepted Ramsar definition of a wetland (Scott & Jones 1995) some 30 natural wetland types are recognized (Scott 1989a). There is often great confusion and sometimes controversy locally over whether a given type of habitat is or is not a wetland. This can even occur in countries with well established wetland classifications and ongoing national wetland inventories such as the United States (Environmental Defense Fund and World Wildlife Fund 1992). The purpose of wetland classification is to standardize and define the terms being used to describe the various wetland types. At an international level a uniform set of terms is needed (Cowardin & Golet 1995; Scott & Jones 1995; Zoltai & Vitt 1995). However, at a local or national level this may not be necessary (Pressey & Adam 1995), although there would seem to be little argument that the adoption of standardized terms and definitions has definite advantages for comparative and broad planning purposes (Cowardin & Golet 1995; Hughes 1995; Zoltai & Vitt 1995).

Techniques used in wetland inventories vary from basic field and literature surveys (Hughes 1995; Taylor *et al.* 1995; Pressey & Adam 1995) to highly sophisticated technological approaches using aerial photography (Taylor *et al.* 1995; Wilen & Bates 1995; Zoltai & Vitt 1995) and satellite imagery (Menantean 1991; Nakayama 1993; Hess *et al.* 1990). To be effective in promoting the conservation of wetlands these inventories must be available to and understood by all those formulating and implementing wetland management policies (Federal Geographic Data Committee, Wetlands Subcommittee 1994, Naranjo 1995; Pressey & Adam 1995; Wilen & Bates 1995). Thus, they must be framed in a manner suitable for management purposes. Additionally, to remain useful tools for management they need to be regularly reviewed and updated (Naranjo 1995; Scott & Jones 1995; Wilen & Bates 1995). At an international level the inventories need to be comparable and available in commonly used languages (Hughes 1995).

Wetland classification

The starting point for many wetland inventories is the development and adoption of a wetland classification. The wetland literature contains a large number of terms to designate and describe different kinds of wetlands. This has partly come about because wetlands occupy an intermediate position between truly terrestrial and aquatic ecosystems and therefore encompass a diverse array of habitats. This array of habitats is difficult to define and a multiplicity of terms has sprung up in many languages to describe wetland types (Cowardin & Golet 1995; Gopal *et al.* 1990; Pakarinen 1995; Scott & Jones 1995). Unfortunately, this richness of terms can make classification an exceedingly difficult task if uniformity of terms and comparability are major parts of the exercise. If these are not important objectives, then one potential stumbling block to classification is removed (Pressey & Adam 1995). However, Cowardin & Golet (1995) argue that at a national level, in the USA, consistency in concepts and terminology were one of the purposes of the development of the US wetland classification system. Furthermore, Cowardin & Golet (1995) support the adoption of an international classification system that incorporates the diversity of wetland types from around the world. Such a system would avoid the use of geographically specific terms, but could include regional, national or continental modifiers. With this approach, colloquial fears about adoption of an international system (Pressey & Adam 1995) would be supplanted.

One of the most commonly accepted wetland definitions is that of the Ramsar Convention 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meter'. This definition has been accepted by more than 70 Contracting Parties to the Convention; however, this does not imply wide acceptance of the definition within these countries (Pressey & Adam 1995; Hughes 1995). Often, narrower definitions that reflect unique national or regional wetland characteristics have been accepted (Cowardin & Golet 1995; Lu 1995; Pakarinen 1995; Pressey & Adam 1995). Furthermore, the six meters depth criterion for marine wetlands causes difficulties of delineation (Lu, 1995), particularly for coral reefs that often extend deeper than six meters (Pressey & Adam, 1995; Scott & Jones 1995). Scott & Jones (1995) point out that this is a legacy of the origins of the Ramsar Convention; for greater acceptance of the conservation benefits of having the Convention such historical and outmoded stumbling blocks should be reconsidered.

Many national wetland classifications already exist and more are being proposed (see Brinson 1993, Cowardin & Golet 1995; Gopal & Sah 1995, Lu 1995; Pakarinen 1995; Pressey & Adam 1995; Semeniuk & Semeniuk 1995; Zoltai & Vitt 1995). These invariably incorporate local terms and definitions that are not necessarily known or accepted elsewhere. For national purposes this may not be a major problem, but for comparisons and management at an international level these differences may present difficulties. However, even at the national level it can be extremely difficult to develop a classification that is acceptable to all wetland scientists and experts (Cowardin & Golet 1995; Lu 1995; Pressey & Adam 1995). Management of wetlands that transcend both inter- and intra-national political boundaries is a difficult enough task (e.g. Hollis 1990) without unnecessary confusion over terms and definitions.

One of the most comprehensive and widely applauded wetland classification systems is that developed for the USA by Cowardin *et al.* (1979). This system is described in depth by Cowardin & Golet (1995). Basically, it divides wetlands into systems, sub-systems, classes and sub-classes, along with a series of water regime, chemistry and soil modifiers. It is hierarchical with the system (marine, estuarine,

riverine, lacustrine and palustrine) as the basic unit. The US classification is also accompanied by a list of plants known to occur in wetlands, and also a list of hydric soils.

An alternative approach to classification is that based on the underlying, unifying features of wetlands, i.e. landform and hydrology (Brinson 1993; Semeniuk & Semeniuk 1995). This approach can be used for both coastal and inland wetlands regardless of climate and vegetation types. The hydrogeomorphic classification of wetlands should make it more feasible to develop methods for assessing the physical, chemical and biological functions of wetlands (Brinson 1993).

An international wetland classification has value if it provides readily understood terms, a framework for international legal instruments for wetland conservation, and assists in the dissemination of information (Scott & Jones 1995). Again, under the auspices of the Ramsar Convention an internationally accepted classification system was developed by Scott (1989a). This was based loosely on the USA system (Scott & Jones 1995). In an internationally acceptable classification system the correspondence between globally adopted taxa and more colloquial terms (e.g. bayou, vlei, billabong, jheel, valle etc.) should be addressed, perhaps in an appendix (Cowardin & Golet 1995). However, the use of local terms is generally considered inappropriate at even the national level (e.g. Cowardin & Golet 1995) and for international purposes readily understood descriptors, rather than a multitude of poorly defined and confusing local names are needed.

In developing a classification system Scott & Jones (1995) issue a note of warning concerning the level of sophistication adopted in relation to the amount of information required, particularly where the information is not available. Careful consideration of the need for information and the requirements for management purposes are points strongly made by Pressey & Adam (1995). Furthermore, for large wetland systems a detailed classification of habitats can be extremely cumbersome and possibly irrelevant. By its very nature, wetland classification is beset by problems as it is an attempt to place artificial boundaries on natural continua (Cowardin & Golet 1995; Pressey & Adam 1995). However, the very fact that so many classification systems exist is evidence that some order or standardization of habitat types is required by scientist, managers and policy makers. The ideal classification system would therefore, be everything to everyone; however, due to the very nature of wetlands and management systems, compromises are necessary and boundaries need to be drawn. Acceptance of such artificial delineation should promote unity of purpose and not serve as dampeners to further innovation, as argued by Pressey & Adam (1995).

Purpose of inventories

Wetland inventories are useful in the first stages of developing effective wetland conservation programs (Novitzki 1995, Pakarinen 1995, Taylor *et al.* 1995; Hughes 1995; Naranjo 1995; Scott & Jones 1995; Wilen & Bates 1995). An inventory can assist in identification of conservation priorities, establish the basis for monitoring the ecological status of wetlands, promote awareness of wetland sites and management issues, and facilitate exchange of information and comparisons between sites and regions (Garcia– Orcoyen *et al.* 1992). As importantly, information gathered for inventories can illustrate the economic value of wetlands (Lu 1995) and provide valuable data for resource utilization decisions (Wilen & Bates 1995).

The usefulness of inventories can quickly diminish if they are not regularly updated (Naranjo 1995; Wilen & Bates 1995; Scott & Jones 1995). To enable rapid updating of inventories the data should be stored in a centralized location and easily accessible through standardized or interchangeable computerized formats. Unfortunately, at an international level the information gathered during broad-scale continental wide inventories remains scattered, making coordinated updating extremely difficult (Hughes 1995; Scott & Jones 1995). The collection of minimum data sets and the utilization of Geographic Information Systems can help overcome such limitations (Pressey & Adam 1995; Wilen & Bates 1995).

Maintenance of the Ramsar site database is one instance where a specific and coordinated approach to updating an international inventory is being undertaken (Scott & Jones 1995). However, this inventory is extremely limited and only covers (in November 1993) 641 of the recognized internationally important wetlands in 80 countries around the world. This database will be expanded as more wetlands are added to the Ramsar list of internationally important wetlands.

Inventories are particularly valuable for assessing wetland loss and degradation (Taylor *et al.* 1995; Hughes 1995; Lu 1995; Wilen & Bates 1995). Information on rates of wetland loss and reasons for this loss can prove invaluable for promoting awareness

of issues and developing conservation and restoration programs (Hollis & Jones 1991; Hughes 1995; Wilen & Bates 1995). Once the basic information on wetland occurrence, distribution and status has been collated it is essential that it is utilized as the basis of further conservation effort (Naranjo 1995); otherwise it quickly becomes dated and not seriously regarded by conservation officials. However, even when inventories are available they may only be of limited usefulness (Hughes 1995; Naranjo 1995). This is particularly so where the information is not comprehensive or is restricted in scope and coverage, or is not brought to the attention of governmental officials responsible for setting policies that affect wetlands.

Wetland inventories

A number of international wetland inventories exist, although the first of these, the IBP Project Aqua (Luther & Rzoska 1971) and IUCN Mar list (Olney 1965), were limited in scope and quickly dated. These were followed by inventories emphasizing waterbird habitats in the Western Palearctic (Carp 1980) and Western Europe and North West Africa (Scott 1980). Again, these were not comprehensive and it was not until the publication of Grimmett & Jones (1989) that a thorough inventory of waterbird habitats in all of Europe became available. Fairly extensive inventories are now also available for the Neotropics (Scott & Carbonell 1986), Asia (Scott 1989b), and Africa (Hughes & Hughes 1992; Burgis & Symoens 1987) (see Table 1 and Fig. 1). More recent inventories include those undertaken in Oceania, Australia and New Zealand (Pressey & Adam 1995; Scott & Jones 1995) and others are being proposed for the Commonwealth of Independent States, the Baltic Republics and the Middle East as part of the 1993–96 program for the IWRB.

Thus, at least some information is available for many parts of the world. However, much of this coverage is not comprehensive or needs updating (Lu 1995; Scott & Jones 1995; Naranjo 1995). Unfortunately, many of these international inventories can only be considered as preliminary (Scott & Jones 1995). More thorough and sophisticated techniques are needed to expand the available databases and to make the inventories more useful for conservation management. Further information on wetland functions and data suitable for monitoring ecological change in wetlands is required and needs to be gathered and compiled in a format that allows for ready access and updating (Hughes 1995; Scott & Jones 1995). Furthermore, the data gathered during inventories needs to be carefully examined to ascertain if it is actually required to further the conservation and wise use of wetlands that are continually being degraded or lost (Hughes 1995; Pressey & Adam 1995; Scott & Jones 1995).

A number of national wetland inventories are now available (Taylor *et al.* 1995; Hughes. 1995; Lu, 1995; Cowardin & Golet 1995; Pressey & Adam 1995; Zoltai & Vitt 1995; Hudec *et al.* 1993). Some of these have been spawned by the international inventories (Lu 1995; Silvius *et al.* 1987). However, despite acceptance of the protocols of the Ramsar Convention and recognition of the values of wetlands many countries have yet to undertake detailed nation-wide inventories (Gopal & Sah 1995; Hughes 1995; Taylor *et al.* 1995).

In southern Africa, inventories are restricted to relatively small regions or are not very detailed (Taylor *et al.*, 1995). In many cases these were compiled from soil and vegetation maps originally designed for other purposes. In northern Africa, several countries now have inventories with information on wetland loss and functions (Atta & Sorensen 1992; Maamouri & Hughes 1992). A number of European countries have produced national inventories and many local regional inventories are also available, although the extent of detail varies enormously (Hughes 1995). Many of the European inventories have concentrated on waterfowl habitat with relatively little attention given to other wetland values. However, a great deal of wetland conservation effort has been initiated as a consequence of inventories based on waterfowl criteria (Hollis *et al.* 1992). In Australia, a large number of localized inventories have been produced and a national inventory project has recently been completed (Usbank & James 1993) and linked to an inventory of wetlands in Oceania (Scott 1993). The most comprehensive attempts at national inventories are those undertaken and being updated in the USA (Wilen & Bates 1995) and Canada (Zoltai & Vitt 1995). This effort has not extended to Central and Southern America, nor to Asia despite the enthusiasm generated by the international inventories for these regions (Scott & Carbonell 1986; Scott 1989b); indicating a fatal flaw in the conservation effort associated with the data gathering or inventory projects (Naranjo 1995).

Table 1. Examples of international and national wetland inventories.

Coverage	Reference
International	
Asia	Scott (1989b)
Neotropics	Scott & Carbonell (1986)
Africa	Hughes & Hughes (1992)/Burgis & Symoens (1987)
Oceania & Australia	Scott (1993)/Usbank & James (1993)
Europe	Grimmett & Jones (1989)
Western Europe/north-west Africa	Scott (1980)
National	
Australia	Usbank & James (1993)
China	Lu (1990)
Czechia	Hudec *et al.* (1993)
Egypt	Atta & Sorensen (1992)
France	Leiderman & Mermet (1991)
Greece	Heliotis (1988)
India	DeRoy & Hussain (1993)
Indonesia	Silvius *et al.* (1987)
Namibia	Simmons *et al.* (1991)
Spain	Montes & Bifani (1989)
Switzerland	Marti (1988)
Tunisia	Maamouri & Hughes (1992)
USA	Tiner (1984)

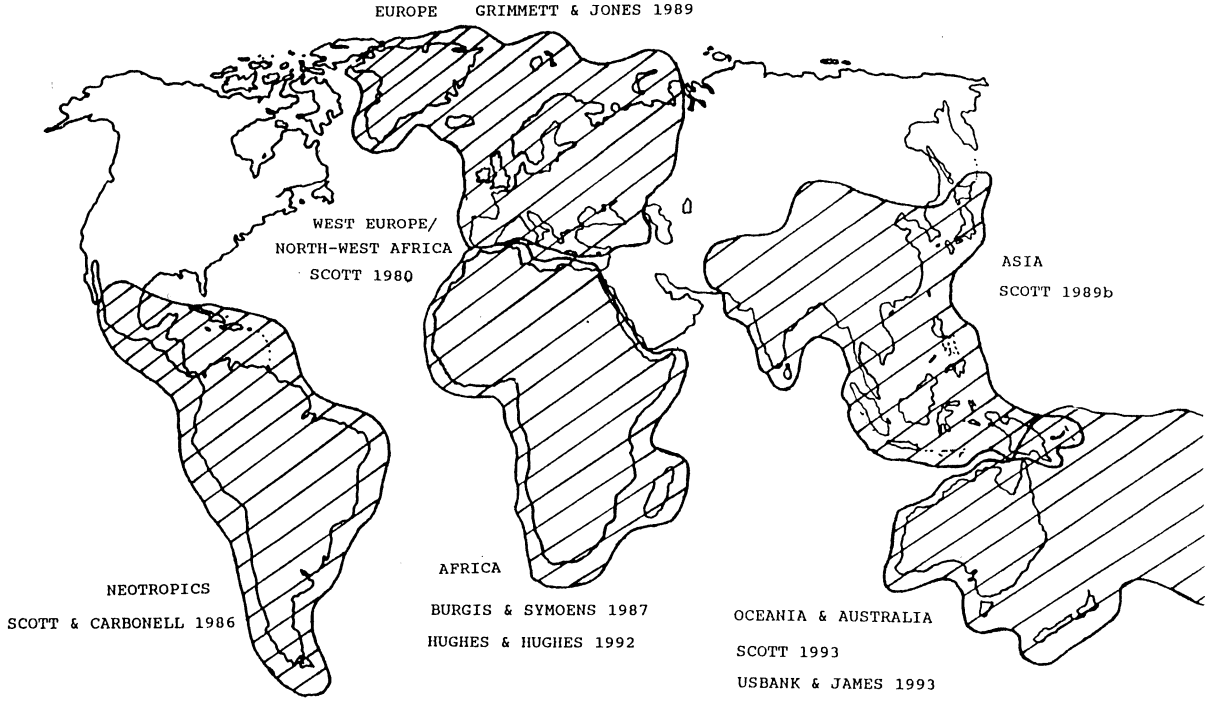

Fig. 1. Areas of the world covered by completed international wetland inventories.

Inventory techniques

Soil, vegetation and topographical maps have proved to be useful sources of information for wetland inventories (Maamouri & Hughes 1992; Pressey & Adam 1993; Psilovikos 1992). However, even where the quality of maps is reasonably reliable they can not always be relied on to provide sufficient information (Taylor *et al.* 1995; Cowardin & Golet 1995). Where maps are available estimates can be obtained by assessing the occurrence of hydromorphic soils or alluvium. In fact, where reconnaissance and literature surveys are utilized for inventory purposes maps are an essential means of locating the wetlands and for assessing the degree of wetland loss. Casado *et al.* (1992) report that during the Spanish wetland inventory around 1500 wetlands were visited; unfortunately this is either not possible nor feasible in many countries. In many instances information and decisions are required before ground studies can be undertaken (Cowardin & Golet 1995).

High altitude aerial photography has been used for wetland inventory purposes in a number of countries (Taylor *et al.* 1995; Psilovikos 1992; Wilen & Bates 1995; Zoltai & Vitt 1995). Problems do occur where the scale varies from region to region and the whole process can be very time consuming and necessitate large numbers of photographs. Despite these problems a large amount of information can be assessed from aerial photography. Interpretation of the data, especially water regimes and vegetation cover can often prove difficult and there is still a need for a high degree of local ecological knowledge (Cowardin & Golet 1995; Pressey & Adam 1995; Zoltai & Vitt 1995).

Orthophotographs which are corrected for height distortion and tilt are being successfully used for wetland inventory in Natal, South Africa (Taylor *et al.* 1995). The photographs are relatively recent and can be used for identification of small wetlands and the data interfaced with other spatial data. As with aerial photographs large scale mapping necessitates the use of large numbers of orthophotographs.

Three satellite sensing techniques are available for wetland inventory purposes. These are the Landsatt Multispectral Scanner (MSS), the Thematic mapper (TM) and the SPOT satellites. All have distinct advantages and disadvantages (Taylor *et al.* 1995). Landsatt MSS data is available, fairly cheaply, for about 20 years in many parts of the world, but the resolution is often not adequate for detecting small linear features. The TM data has only been available in recent years and is much more expensive than MSS data. SPOT data is also useful for inventory purposes and has been successfully used in parts of southern Africa and is being tried in the Mediterranean Basin (P. Tomas-Vives personal comm.). Overall, satellite sensing gives a wide coverage and is particularly valuable for widescale mapping in remote and inaccessible areas. However, the wide scale of the coverage raises problems with accuracy and detail and cloud cover obstructs data acquisition (Wilen & Bates 1995; Zoltai & Vitt 1995). These problems are currently being addressed with that of cloud cover interference being overcome by the use of radar imagery (Hess *et al.* 1990). When satellite data is collected it is possible to interface with other geographic data storage systems and compile comprehensive data bases that can be interrogated and used to test models at different scales.

Conclusions

There is very little demonstrable acceptance of worldwide classification systems for wetlands, reflecting vast differences in approach and goals (see Pressey & Adams 1995; Scott & Jones,1995). The Ramsar classification system, loosely based on the USA example, is possibly one system that does have the capability of being used internationally, at least for the purposes of maintaining comparability and a common language. At a national and regional level the adoption of this common approach to wetland classification has not been widely accepted, probably due to poor promotion by national conservation authorities and wetland experts familiar with the Convention.

Despite the inherent problems in developing widely accepted classifications, much effort, in response to perceived local needs for classification, has been undertaken. A new and innovative system of classification, using landform and wetness, has been developed at a local level and then expanded to then international by Semeniuk & Semeniuk (1995). However, even this system suffers by introducing yet another set of new terms and definitions; a problem that bedevils classification.

Regardless of the classification system adopted, many wetland inventories have been done. These have utilized a variety of techniques. In this respect, the highly sophisticated USA example of using extensive aerial photography to produce wetland status and trends reports (Wilen & Bates 1995) stands out. At the other end of the scale of technical sophistication,

the survey techniques used to produce the first Asian and Neotropical wide (see Scott & Jones 1995) inventories have demonstrated the value of compiling current information; a process also undertaken in Canada (Zoltai & Vitt 1995). However, the sophisticated follow-up effort that occurred in Canada has not been undertaken in the Neotropics, thereby negating some of the conservation value of this inventory (Naranjo, 1995).

From a conservation perspective, the value of an inventory can only be shown by the usefulness of the information for conservation purposes (Naranjo 1995; Pressey & Adam 1995; Scott & Jones 1995). Such shortfalls in the conservation effort stemming from classification and inventory projects could be picked up by the development of a centralized data storage repository under the auspices of international agencies, such as IWRB and the Ramsar Bureau, that are already committed to global wetland conservation programs.

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